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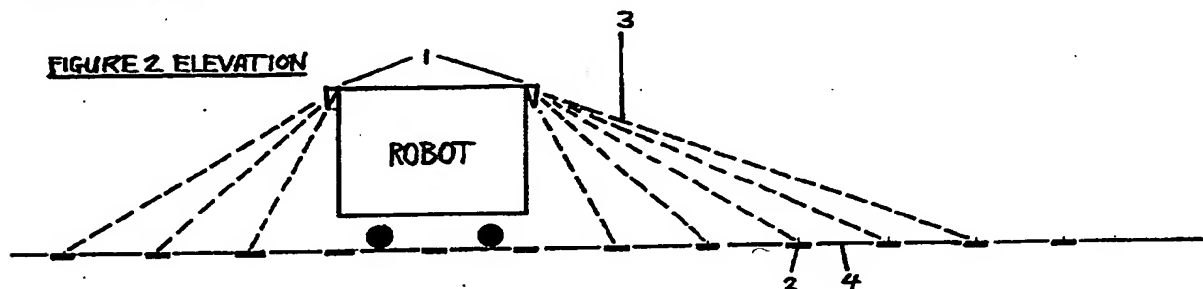
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(56) Documents Cited  
GB 2325578 A GB 2316484 A GB 2236261 A  
EP 0423026 A1 EP 0364353 A1 EP 0236614 A2  
WO 95/29380 A1 WO 89/03075 A1 WO 88/04081 A1  
WO 85/05474 A1 US 5258822 A US 5235513 A  
US 4811228 A

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(54) Abstract Title  
**Robot positioning and obstacle sensing**

(57) The surface(4) on which the robot moves is marked with visual markers(2) painted on the road surface. A moving robot that has dead reckoning capabilities and cameras(1), uses the expected robot position and the positions of the visual markers from a database, to determine the expected position of the markers in the camera. Any difference between the expected and observed view is used to improve the estimate of the robot position. If a disk is wholly visible in the image then a fall safe deduction is that the space(3) between the disk and the camera is free of obstructions. If the disk appears obscured then a working assumption is that the space is obstructed.



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FIGURE 1 PLAN VIEW

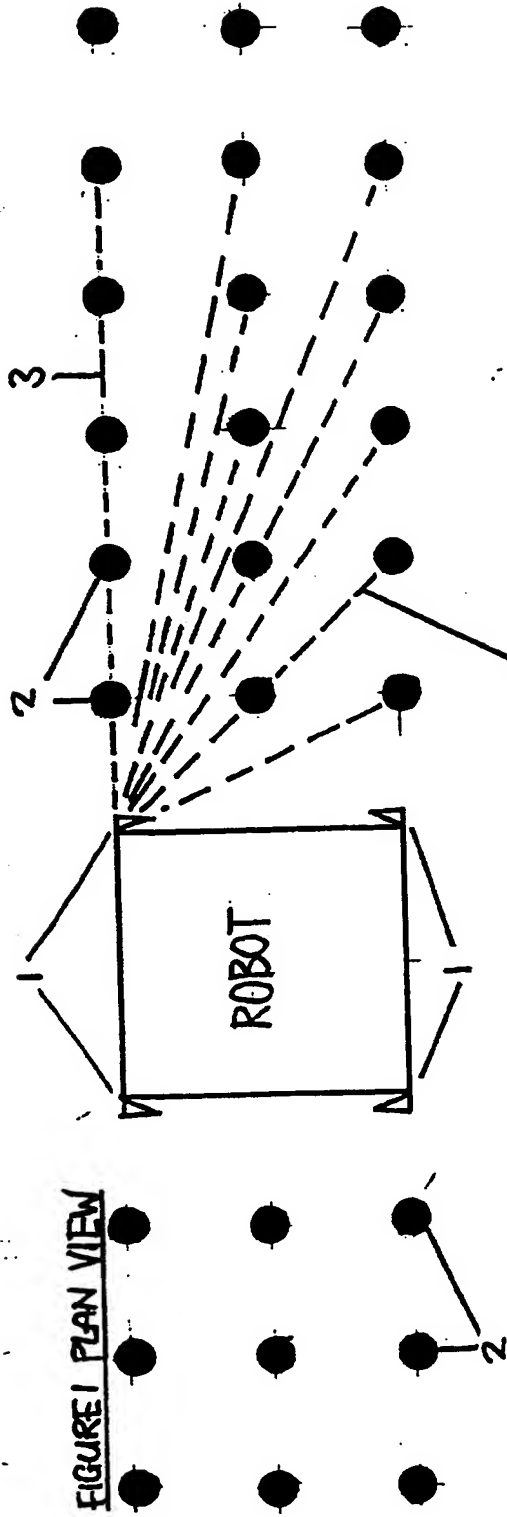
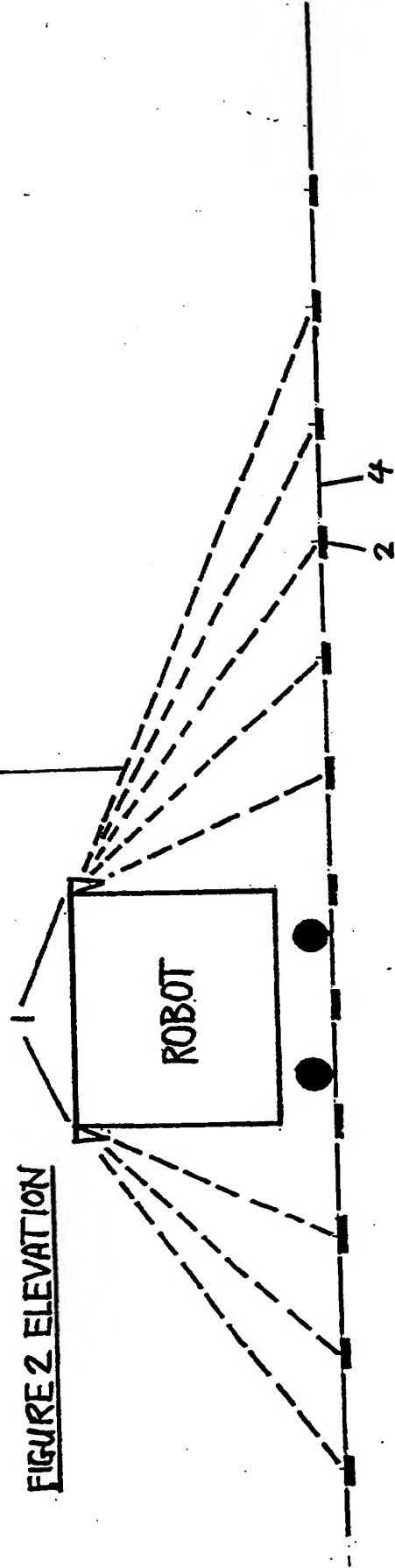


FIGURE 2 ELEVATION



## ROBOT POSITIONING AND MOTION MECHANISM

This invention relates to use of computer vision in the positioning of a mobile robot and the determination of obstacle free paths for the robot.

In order to change position, a robot must know its current position, and whether there is a clear path to the new position. There are many ways of doing this, and not all methods are visual.

The invention comprises the following components:

- A number of identical visual markers(2) on the surface of the road(4).
- A database containing:
  - the positions of the visual markers
  - the marker topology, so that the robot can determine from one marker, the identifiers of adjacent markers.
- Cameras(1) attached to the robot capable of viewing nearby markers.
- A computer system capable of:
  - controlling the robot motion
  - determining the change in robot position by dead reckoning
  - obtaining marker information from the database
  - determining whether a marker should be visible from a particular camera
  - detecting visual markers in the camera image, given a estimated position

The operation of the invention will now be described.

The computer system must be initialized with the current location of the robot in relation to the visual markers. When the robot changes position, the computer estimates the new position by dead reckoning. Using this estimated position, the computer accesses the database to find visual markers that are adjacent to the robot, and a set of markers that are in view of the cameras is determined. From the robots estimated position, and the position of the markers, the expected position of the markers in the camera view is determined. Any slight difference between the expected and observed position in the camera image is used to correct the estimate of the robots position. In this way the robot is able to correct errors in dead reckoning, and to know its position in relation to the visual markers..

Where a visual marker is expected in the image view, but is not visible or not completely visible in the image, the space(3) between the visual marker and the robot is presumed to be blocked by an obstacle. In this way it is possible to determine whether the space to a visual marker is free of obstacles. This mechanism is fail safe in that it requires the positive identification of a marker in the image to determine that the space is clear, rather than the negative, no obstacle is found.

The motion of the robot is specified in terms of the visual markers. For example the robot is commanded to move to a given marker name, and the route from the current position to the desired position can be determined in terms of markers.

The marker positions may be 2 dimensional where the robots environment is a horizontal flat road base, and will be 3 dimensional where the robots environment is sloping or undulating.

## CLAIMS

1. The use of a database of the positions of identical visual markers, the estimated position of the robot, the expected and observed positions of markers in the camera image to correct errors in the estimated position of the robot.
2. The use of expected visual marker sightings that are missing or incomplete to determine the presence of obstacles.
3. The use of expected visual marker sightings that are present in the image to determine the absence of obstacles.
4. The use of a database of the positions of identical visual markers to specify and calculate a path from the current robot position to the desired robot position.



Application No: GB 9920372.1  
Claims searched: 1, 4

Examiner: Dr E.P. Plummer  
Date of search: 12 April 2000

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:  
UK Cl (Ed.R): H4D (DLAA, DLAB, DLFB, DLPC, DLPG, DLPX)  
Int Cl (Ed.7): G01C, G01S  
Other: Online: WPI, PAJ, JAPIO

**Documents considered to be relevant:**

Category	Identity of document and relevant passage		Relevant to claims
X	GB2325578A	EVANS & SUTHERLAND	4
Y		whole document	1
X	GB2316484A	KOMATSU LTD	
		whole document	4
		& WO96/37756A1	
X	GB2246261	ROKE MANOR RESEARCH	
		whole document	4
X	EP0423026A1	MICROMAINE	
		whole document	4
X	EP0364353A1	COMMISARIAT A L'ENERGIE ATOMIQUE	
Y		whole document	1
X	EP0236614A2	SI HANDLING SYSTEMS	
Y		whole document	1
X	WO95/29380A1	SIMAN SENSORS & INTELLIGENT MACHINES LTD	
		whole document	4

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.



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**Claims searched:** 1, 4

**Examiner:** Dr E.P. Plummer  
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Category	Identity of document and relevant passage		Relevant to claims
X	WO89/03075A1	SECRETARY OF STATE / DTI whole document	4
X	WO88/04081A1	DENNING MOBILE ROBOTICS whole document	4
X Y	WO85/05474A1	GENERAL ELECTRIC COMPANY whole document	4 1
X	US5258822	HONDA GIKEN KKK whole document	4
X	US5235513	VEGLER & TOCKER eg figure 5 embodiment & GB2224613A	4
X	US4811228	INIK INSTRUMENT OCH ELEKTRONIK whole document	4

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